

Science Teacher Education and the Nature of Science: A Voice from Pakistan

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The purpose of this paper is to advocate that teachers be encouraged and helped to develop an overt and clear epistemological understanding of the methods and structure of science, i.e., the nature of science (NOS). I have tried to define the concepts that constitute NOS essential for school science. I also want to highlight some of the challenges faced in attempts to introduce NOS in inservice teacher education in Pakistan.

Pakistan faces intractable problems in education in general (Hayes, 1987) and teacher education in particular (Khalid, 1996). However, over the last decade a number of teacher education institutions like the Aga Khan University, Institute for Educational Development (AKU-IED) and Ali Institute of Education, to name only few, are changing the landscape of teacher education in Pakistan by providing field-based teacher education.

Teacher education programs in Pakistan do not include NOS as part of their syllabus. However, the science curriculum for pupils from classes one to eight does address NOS by including, "scientific literacy" as one of the aims of teaching science (Government of Pakistan, 2000). Scientific literacy assumes an understanding of NOS (Driver, Leach, Millar & Scott, 1996). My experience has shown that science teachers in Pakistan have not given sufficient attention to this essential aim of science education because their own experiences as science students has not prepared them to deal with this component of science. Furthermore, pre-service and inservice teacher education programs do not prepare teachers to teach *about science* - the focus is more on teaching content knowledge and methods of teaching.

Reconceptualizing Science Teacher Education

The reconceptualization of curriculum in the 1970's and 1980's has encouraged a view that rejects the concept of a curriculum as an abstract

concept, which has some existence outside and prior to human experience. "It is not on the teacher's shelf that one looks for the curriculum, but in the actions of the people engaged in education" (Grundy, 1987, p. 5). Within this conception of curriculum, teacher development and curriculum development is a dialectical process. Many countries that are restructuring and reforming their educational systems and curricula to meet the needs of the postindustrial age have recognized that the teachers are the keys to educational change. That educational innovations cannot succeed if teachers are not taken into account is a lesson that is being slowly learnt. Hence, if change is to occur in the way science is taught, it has to be mediated through the teacher. Only by bringing a change in the teacher's way of thinking, will the change be long lasting. Another reason that I advocate a reconceptualization of teacher knowledge about NOS is because it is always present as the "hidden" curriculum (Dreeben 1976). The NOS has never been absent from the curriculum, it is just never explicitly stated (Matthews, 1994).

Need for NOS in Teacher Education

Including NOS in school science is not a new or novel proposal. Dewey (1916) put forward the argument that understanding scientific method is more important than the acquisition of scientific knowledge. Schwab (1964) echoes the same views when he complains that science is taught as a "rhetoric of conclusions" rather than enquiry. Consensus about the importance of NOS in school science is extensive; many different professional organizations, such as the Association for Science Education (1981) in Britain and the National Science Teachers Association (1995), have embraced the call for including NOS in school science curriculum.

Despite the prevailing consensus for demands for inclusion of NOS in school science, there is ample

research evidence that, irrespective of academic background, science teachers possess a limited knowledge about NOS (Koulaidis & Ogborn, 1995; Mellado, 1997). Benson (1989) has noted that many science teachers misunderstand and misrepresent NOS. Tobin and McRobbie (1997) believe this to be a problem, because the teachers' views of NOS can influence their students' conceptions of science. However, the influence of teachers' conceptions of NOS on their classroom practice has not been adequately researched. McComas, Almazroa and Clough (1998) contend that while the relationship between the teacher's NOS knowledge and their pedagogical decision-making is not straightforward, a complex interplay does exist. Therefore, it comes as no surprise that pupils have alternate frameworks about NOS, (Ryan, 1992). There is research evidence, albeit limited, that science teachers in Pakistan also have an inadequate understanding of NOS (Halai, 1999). Not knowing *about* science, the science teachers continue to teach science as a collection of facts. The vicious cycle of science-as-collection-of-facts approaches to science teaching breeds students, who go on to become teachers, and who emulate their teachers, and the cycle continues. It is important that this cycle is broken.

What is meant by NOS?

The dilemma is that before an understanding of NOS can be fostered in students, the science teachers need to have a fairly sophisticated understanding of it. The NOS, because it is both a problematic and contentious concept, is difficult to define. Hodson (1991) agrees and writes that "while it is apparent that no single, universally accepted view of science emerges from a consideration of the literature, there is a measure of agreement on a number of points relevant to the school science curriculum" (p. 21). The NSTA in a position paper (2000) has listed the concepts of NOS that are important for school science. I have provided, below, an abbreviated copy of this list:

- Scientific knowledge is simultaneously reliable and tentative.
- Although no single universal step-by-step scientific method captures the complexity of doing science, a number of shared values and

perspectives characterize a scientific approach to understanding nature.

- Creativity is a vital, yet personal ingredient, in the production of scientific knowledge.
- A primary goal of science is the formation of theories and laws, which are terms with very specific meanings.
- Contributions to science can be made and have been made by people the world over.
- The scientific questions asked, the observations made, and the conclusions in science are to some extent influenced by the existing state of scientific knowledge, the social, cultural context of the researcher, and the observer's experiences and expectations.
- The history of science reveals both evolutionary and revolutionary changes. With new evidence and interpretation, old ideas are replaced or supplemented by newer ones.

Challenges Faced In Teaching about NOS

While teaching a science methods course as part of a team¹ at AKU-IED, I studied three elementary teachers' developing understanding of NOS, while engaged in practical hands-on science. The predominant mode of data collection was interviews. The analysis of the data gives some understanding into how elementary teachers, who do not necessarily have preparation in science, learn about NOS in the context of Pakistan. The findings indicate that practical, hands-on activities are helpful, but there is a need for more overt teaching of NOS and explicit discussion of the concepts of NOS, as they relate to each practical activity. The two teachers who did not have a background in science had difficulty in border crossing from their own subject sub-culture/s to the culture of science. But, the surprising finding was that the third teacher, who was a science teacher, had greater difficulty in accepting ideas about NOS such as: most scientific observations are theory based. It is my conjecture that the science teacher being socialized in a very positivistic conception

1. Their names in alphabetical order are Ms. Charan Pardhan, Dr. Sadruddin Pardhan, and Dr. Alan Wheeler.

of science had more difficulty in changing beliefs, as compared to the other two teachers, who did not have much experience of learning and teaching science.

It is clear that reconceptualizing the ideas about NOS is very important for science teachers and science teacher educators. This study gives an insight into the difficulty of the process of bringing about such change. It has also raised a number of questions, the most important being: What does NOS mean in the context of a Muslim society like Pakistan? I support an inquiry approach to the introduction of NOS to teacher education curriculum in Pakistan, so that we learn in the process of implementation of this policy.

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